40-FT. REVOLVING DOME

for

STOCKHOLM OBSERVATORY.

SIR HOWARD GRUBB, PARSONS & CO.,

Optical Works:

WALKER-GATE,
NEWCASTLE-ON-TYNE,
ENGLAND.

FORMERLY SIR HOWARD GRUBB & SONS, LTD., OF DUBLIN & ST. ALBANS.

Reprinted from

"ENGINEERING,"

February 20, 1931.

LONDON:
OFFICES OF "ENGINEERING," 35 & 36, BEDFORD STREET, STRAND, W.C. 2.

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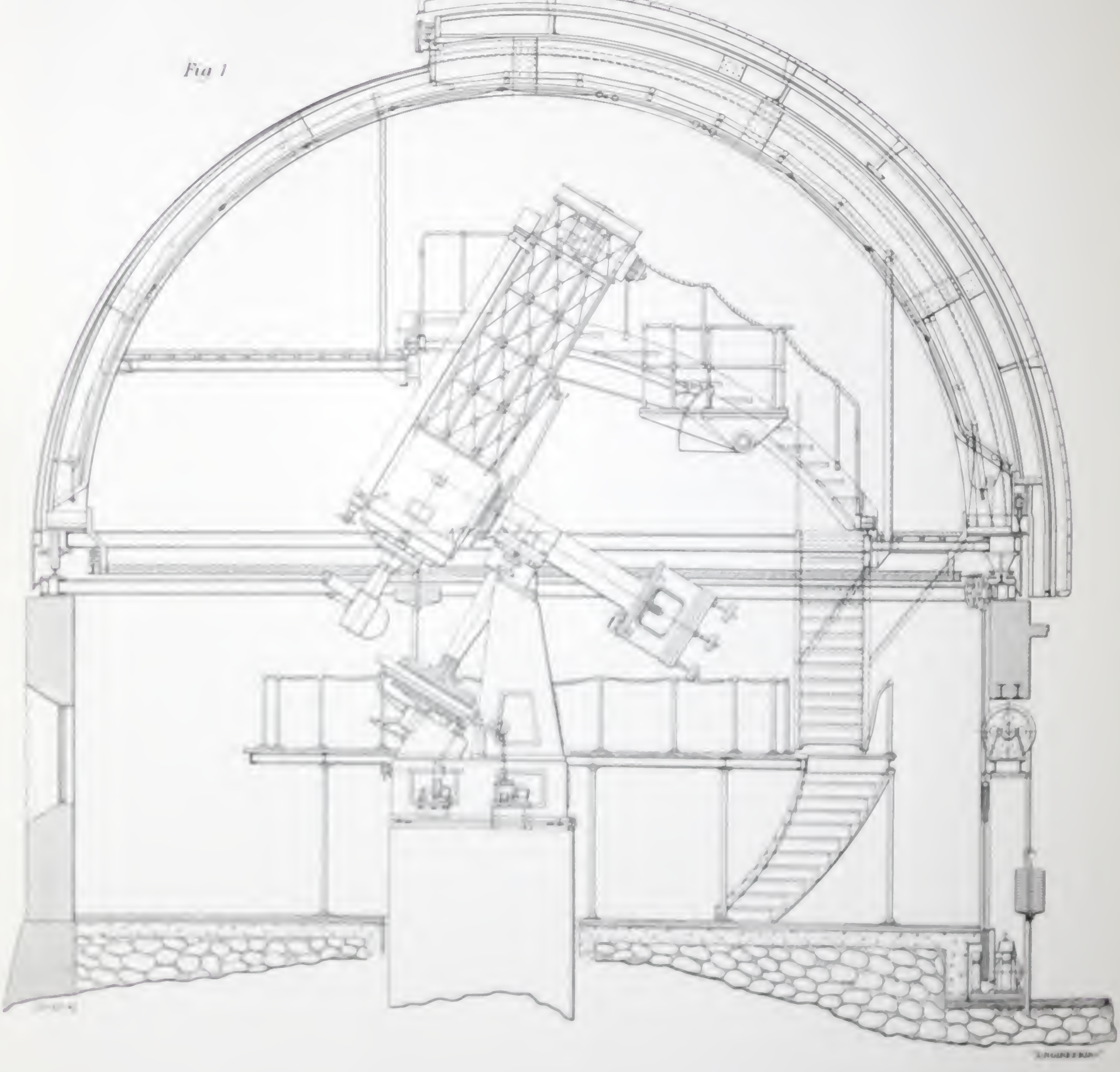
As the centre of a large city is a by no means ideal locality for carrying on the precise observations of which modern astronomical instruments are capable, it was decided, some two and a half years ago, to remove the Stockholm Observatory to Saltsjöbaden, which is situated about 10 miles from the city. Advantage was taken of the opportunity thus afforded of fully modernising the equipment of the observatory, and it is satisfactory to be able to state that the order for practically the whole of the new equipment was obtained by a British firm, Messrs. Sir Howard Grubb, Parsons and Company, of Walker Gate, Newcastle-on-Tyne, in spite of severe competition from Continental manufacturers. The order comprised a twin refractor with 24-in. photographic and 20-in. visual objectives, and a 40-in. reflector, together with the revolving domes, which form the roofs of the observatory buildings in which the two telescopes are housed. The reflector, it may here be remarked, is arranged so that either the Cassegrainian or Newtonian optical systems can be employed for visual or photographic work. Both telescopes were designed and constructed by Messrs. Sir Howard Grubb, Parsons and Company, in accordance with the requirements of Professor Bertil Lindblad, the Director of the Observatory, and the reflector mounting was delivered in December last; the refractor mounting, it is anticipated, will be completed in about two months' time.

The arrangement of the former can be followed from Fig. 1, on page 4, which shows a section through the building in which it is now being erected. As will be seen, the design is generally similar to that of the 36-in. reflector for Edinburgh Observatory, which was exhibited on the stand of Messrs. C. A. Parsons and Company, Limited, at the North-East Coast Exhibition, Newcastle-on-Tyne, in 1929, and was described in considerable detail in ENGINEERING, vol. cxxviii, pages 288, 371, 431 and 488, of the same year. The Edinburgh instrument, however, is used as a Cassegrainian only, and mainly for spectrographic work. The Stockholm reflector will also be used for this purpose, and will be fitted with a spectrograph at the Cassegrainian end, and with a slitless spectrograph at the Newtonian end; the spectrographs are, however, being supplied by Messrs. Zeiss, of Jena. A noteworthy feature of the twin refractor is that the photographic telescope is being fitted with a double-slide plate holder, having guiding microscopes which enable any apparent movement of a star to be corrected by moving the plate instead of the whole telescope. A similar plate holder, interchangeable with a guiding breech-piece and also with a bifilar micrometer, is being supplied for the visual telescope. Both instruments, as would be expected, include many other interesting details, but, for the present, we propose to confine our attention to one of the observatory domes, viz., that for the 40-in. reflector. We select this for description, since it includes a novel form of travelling observing platform provided to give convenient access to the Newtonian focus, which is located, of course, near the upper end of the tube. Both domes were completed and despatched in May last. They are 40-ft. 2-in. in external diameter, and both are of generally similar construction, but, as, with the refractor, the whole of the observations are made from the breech end, a rising floor is provided in the building containing this instrument, and the travelling platform is omitted.

The requirements of an observatory dome are that it must permit the telescope to be directed easily and rapidly to any part of the celestial hemisphere, and at the same time afford the maximum protection to the observer and instrument against the weather while the observations are in progress. These requirements are most conveniently met with a hemispherical dome having a radial slot extending from the lower edge to a point well beyond the zenith, the slot being provided with laterally moving shutters, which can be closed completely when the instrument is not in use, and with fabric screens to cover the parts of the slot above and below the telescope tube. Fig. 2, on page 5, shows the dome erected complete, with the exception of the roof-covering material, at Messrs. Sir Howard Grubb, Parsons and Company's works. On the left, the two shutters can be seen in the closed position, while one of the fabric screens is visible inside the dome on the right. The man is standing on a curved bridge stairway, which can be moved in a lateral direction, as required, and, on the left of this stairway the observing platform is mounted in such a manner that it can travel up and down along the stairway, although it always remains in a horizontal position.

Referring again to Fig. 1, page 4, it will be seen that the whole dome is mounted on a foundation ring bolted on to the circular wall of the observatory building. This ring, which is shown in section on a larger scale in Figs. 16 and 17, on the Plate, is built up of two 7-in. by $3\frac{1}{2}$-in. channels, with $\frac{3}{4}$-in. cover plates top and bottom. To this ring a 40-lb. B.S. flat-bottomed rail, bent

Fig 1



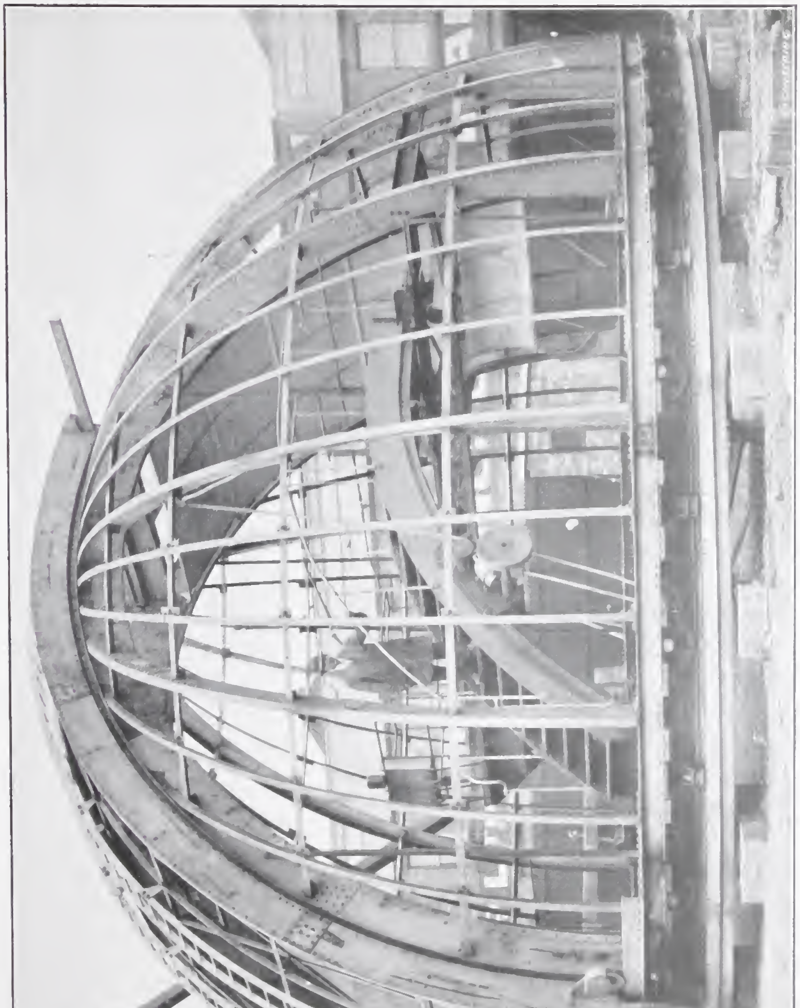


Fig. 2. Dome Erected at Makers' Works.

Fig. 3. Bridge Stairway and Observing Platform.

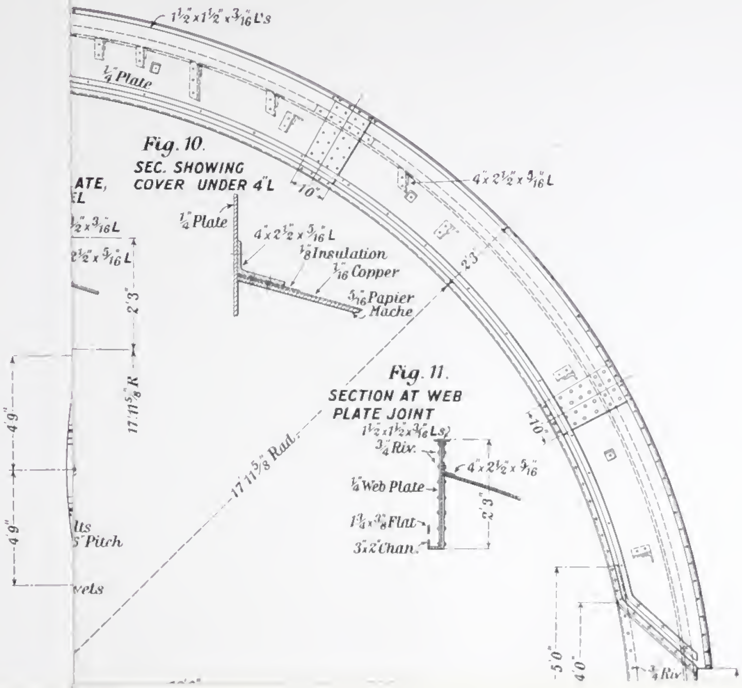


Fig. 10.
SEC. SHOWING COVER UNDER 4" L
1/4" Plate
4" x 2 1/2" x 3/16" L
1/8 Insulation
1/16 Copper
3/16 Papier Mache
Fig. 11.
SECTION AT WEB PLATE JOINT
1 1/2 x 1 1/2 x 3/16 L's
3/4 Riv.
4" x 2 1/2" x 3/16
1/4 Web Plate
1 3/4 x 3/8 Flat
3" x 2" Chan.
1 1/2" x 1 1/2" x 3/16" L's
1/4 Plate
4" x 2 1/2" x 3/16" L
17' 11 5/8" Rad.
17' 11 5/8" R

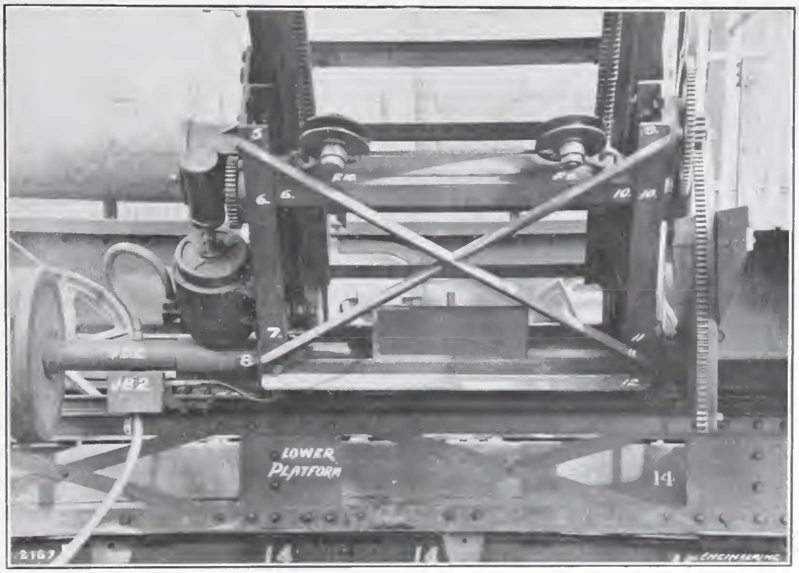


Fig. 28. Climbing and Levelling Gear for Observing Carriage.

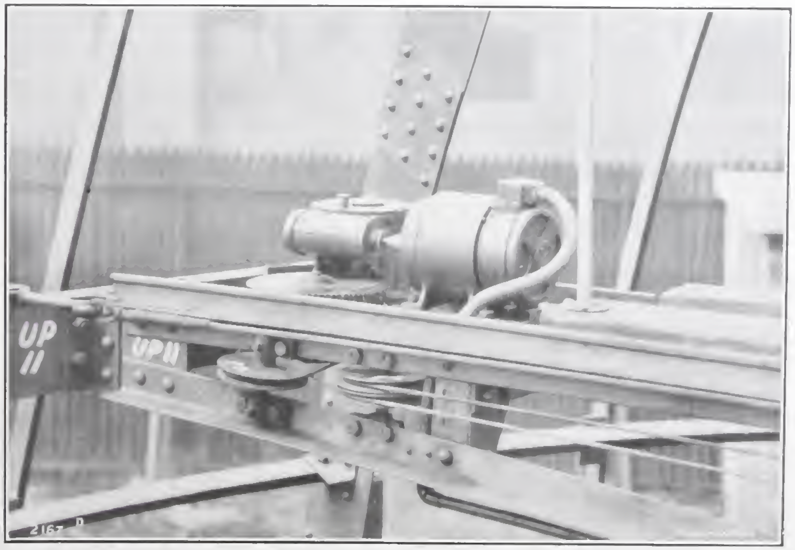


Fig. 29. Traversing Gear for Bridge Stairs.

to a radius of 19 ft. 4 in. on the centre line, is secured by means of clamping plates. The bottom ring of the dome itself is built up of a pair of 8-in. by $3\frac{1}{2}$-in. channels, the upper flanges of which are braced together by plates at intervals, as is most clearly shown in the plan, Fig. 4, on the Plate. On the lower flanges are mounted the housings for the Skefko ball bearings of the main rollers, which run on the curved rail previously mentioned. The rollers, of which 16 are employed, are of cast-iron, 18 in. in diameter, and are made without flanges to facilitate erection; details of them are given in Fig. 17, on the Plate. To prevent lateral movement, 16 pairs of horizontal rollers located midway between the vertical rollers are provided, these rollers, which are flanged, running on the sides of another sheave and having a counterweight suspended from it, as will be clear on reference to Fig. 1. The motor for rotating the dome is controlled by a push button located on the observing platform, the necessary connections for this purpose, as well as for the supply of current to various motors mounted on the rotating parts, being made through roller contacts running on copper strips, suitably insulated, and carried by the bent angles which support the channel ring above referred to. The strips are shown in section on the right of Figs. 16 and 17, on the Plate. The motor can also be controlled from the floor of the building. The electrical supply, it may be mentioned, is in the form of continuous current at 100 volts.

The general design of the steelwork forming the

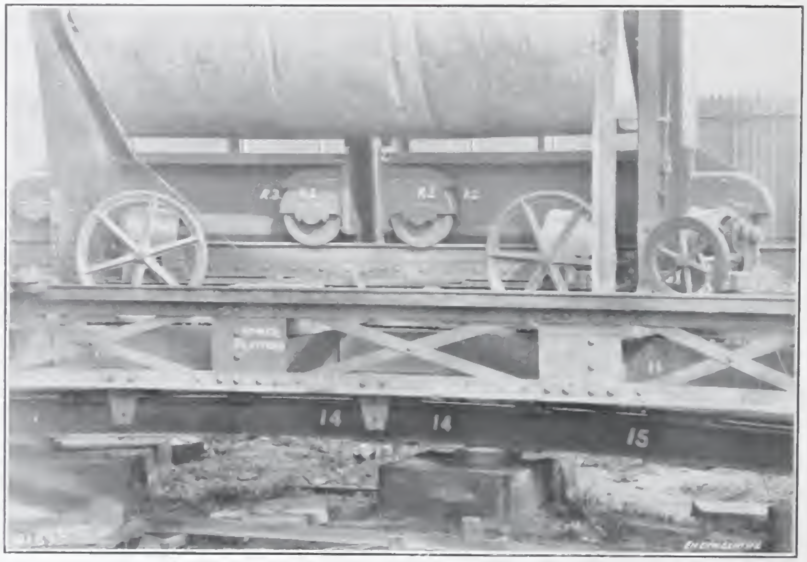


Fig. 30. Gear for Operating Wind Screens and Shutters.

the rail head, as shown in Fig. 16. They are mounted on ball bearings on short vertical spindles, each pair being carried by a casting bolted on to the lower flanges of the channels forming the bottom ring of the dome. The rotation of the dome is effected by means of an endless wire rope operated by a 4-h.p. motor arranged as shown in Fig. 1, on page 4. The rope passes round a channel ring attached to the bottom ring of the dome by bent angles, as shown on the right in Figs. 16 and 17, on the Plate, and is then taken over two sheaves down to the winding drum, which is driven by the motor through worm reduction gearing. The rope is kept taut by passing it round a movable sheave located above the winding drum, the movable sheave being pulled upwards by a rope passing over spherical portion of the dome, which was supplied by Messrs. J. Lysaght, Limited, of Bristol, can best be followed by examining Fig. 2 on page 5, in conjunction with Fig. 4 on the Plate. From the latter it will be seen that there are two main girders forming the sides of the opening and placed parallel with a diameter at a distance of 4 ft. 9 in. on each side of it. The clear width of the opening is 9 ft., and it extends 4 ft. beyond the zenith. An elevation of one of the main girders is given in Fig. 5, on the Plate, and from this figure and the various cross sections reproduced in Figs. 6 to 12, details of its construction can be obtained. Between these girders and parallel with them, in the space opposite the opening, are two ribs formed of 3 in. by 3 in. by $\frac{1}{4}$ in. angles, and angles of the same dimensions are

used for the four purlins. There are two forms of radial ribs, those marked "Rib A" in Fig. 4, consisting of a $\frac{1}{4}$-in. plate, 12 in. in radial depth, with a 3 in. by 3 in. by $\frac{1}{4}$ in. angle riveted along the outer edge; the two ribs between these main ribs are formed from $2\frac{1}{2}$ in. by $2\frac{1}{2}$ in. by $\frac{1}{4}$ in. angles. The roofing material used was a form of papier mâché, known as Agasote, and supplied by Messrs. G. D. Peters and Company, Limited, of Slough, this material having the advantage of being light and strong, and easily bent to the necessary spherical curvature. The sheets used were $\frac{3}{8}$-in. in thickness, and a covering of No. 24 gauge sheet copper was applied externally.

The two rolling shutters which close the opening in the dome are each built up of two light plate girders, braced together, and having an intermediate rib and angle purlins to carry the roofing material. Details of their construction are given in Figs. 18 to 27, on the Plate. Each shutter is supported on a pair of rollers at each end, the rollers at the upper end running on the edge of a 5 in. by 3 in. by 9 lb. bulb angle attached to the main girders, and those at the lower end on a 7 in. by 3 in. by 14 lb. bulb angle connected to the bottom ring of the dome. Steel ladders are mounted on the shutters, as shown in several of the figures, to give convenient access to the track and rollers at the upper end for clearing away snow. The shutters are opened and closed by hand gear which will be referred to later.

A photograph of the observing platform, to which reference has already been made, is reproduced in Fig. 3, on page 6, and a side elevation of it, and of the bridge stairway on which it is mounted, is given in Fig. 13, on Plate. The upper end of the stairway, which is 3 ft. wide and 19 ft. 6 in. long, in plan is fitted with transverse rollers which run on rails fixed to the edge of a platform supported from the main ribs of the dome, as is most clearly shown in Fig. 1, on page 4. Similar rollers fitted to the lower end of the stairway run on a rail which is fixed to a girder attached to the bottom ring of the dome, as shown in Fig. 3, on page 6. The stairway can be traversed laterally by means of a $\frac{1}{2}$-h.p. motor which drives, through worm and spur reducing gearing, a drum, on which a wire rope is wound. The rope passes round sheaves and runs along the front edge of the upper platform and back to the drum, as shown in Fig. 29, on page 7, and, as the stairway is attached to the rope, it can be pulled along in either direction according to the direction of rotation of the motor, which is controlled from the observing platform.

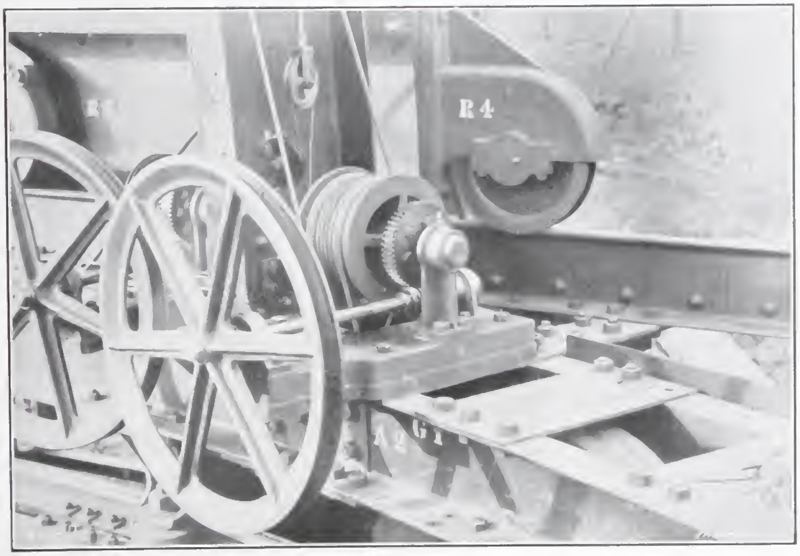


Fig. 31. Shutter-Operating Gear.

The latter is 4 ft. 9 in. long and 3 ft. 6 in. wide, and is mounted on one side of a carriage fitted with four rollers which run in channels attached to the strings of the stairway, a balance weight being mounted on the opposite side of the carriage, as shown in Fig. 3, on page 6. A $\frac{1}{2}$-h.p. motor, mounted on the balance-weight side of the carriage, is used to propel it along the stairway, the motor driving, through worm and spur reduction gearing, a shaft on which are mounted two pinions engaging with racks fitted on the strings. The propelling arrangements are shown in Fig. 14, on the Plate, and in Fig. 28, on

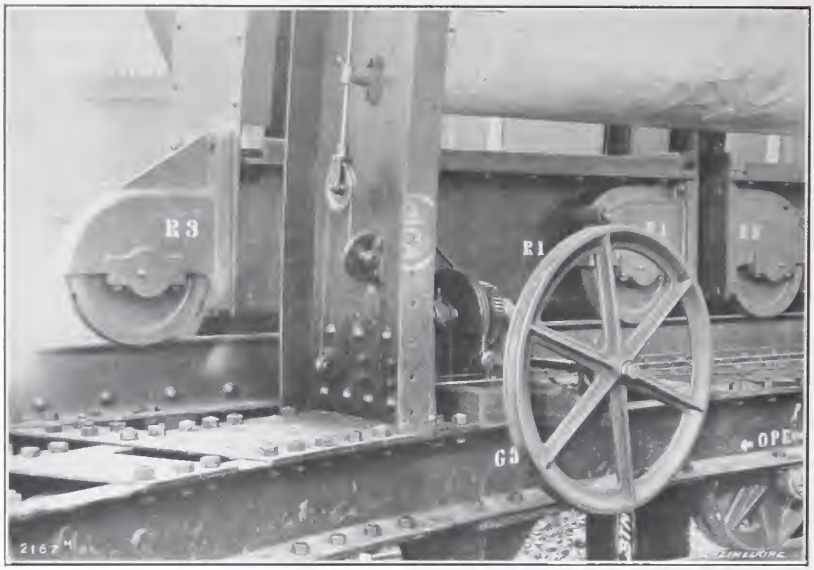


Fig. 32. Gear for Operating Upper Wind Screen.

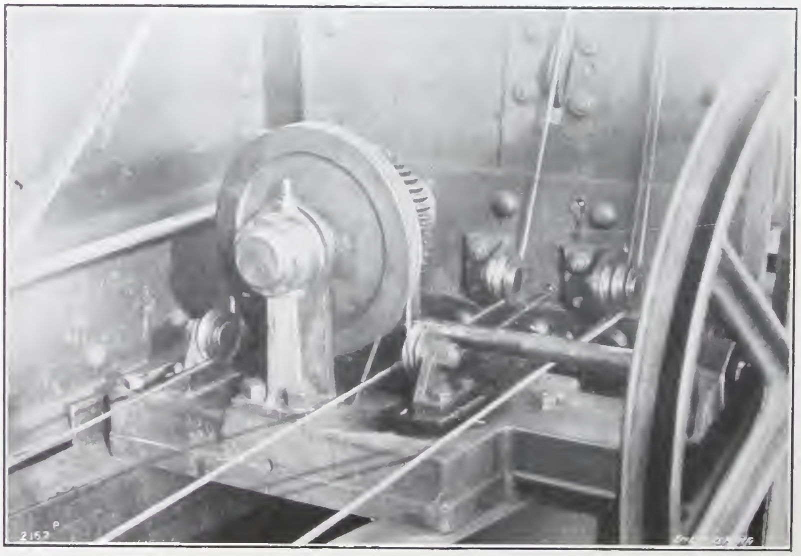


Fig. 33. Gear for Operating Lower Wind Screen.

page 7. The latter illustration shows the mechanism employed to keep the observing platform in the horizontal position at any point in its travel along the stairway. The platform, it should be mentioned, is mounted on a shaft extending from the carriage, and is turned about this shaft, to compensate for the curvature of the stairway, by means of a toothed quadrant shown on the right in Fig. 28, on page 7. A small pinion on the end of the shaft on which the two main propelling pinions are mounted engages with a gear wheel on a short shaft which also carries a pinion engaging with the teeth of the quadrant, and the gear ratio between the first-mentioned pinion and the quadrant has been arranged to give the required angular movement to the platform as it travels along the stairway.

To equalise the load on the propelling motor, the weight of the travelling carriage and platform is balanced by means of a counterweight, the arrangement adopted being illustrated diagrammatically in Fig. 15, on the Plate. For this purpose, a wire rope, fixed at one end to a hook on the upper platform, as shown on the left in Fig. 29, page 7, is taken round four sheaves, two on the stairway and two on the carriage, the latter being shown in Fig. 28, and led over another sheave down to the counterweight in the manner illustrated in Fig. 15. Since the inclination of the stairway is considerably greater at the lower end than at the upper end, the weight required to balance the carriage will decrease as it ascends. For this reason, one of the weights is made wider than the others, and as the counterweight descends, this weight, and those above it, are retained by stops fixed to the guides, so that the weight of the counterweight is reduced. These weights are, of course, picked up and added to the counterweight as the carriage descends and the counterweight rises.

Fig. 30, on page 8, shows the gear for operating the wind screens and rolling shutters, the latter gear, seen on the right in Fig. 30, being shown to a larger scale in Fig. 31. The shutters are operated from the floor of the observatory by a rope passing round the grooved pulley shown in Fig. 31, a worm on the pulley shaft engaging with a wormwheel on a shaft which also carries a winding drum, on which is cut a helical groove. A steel cable makes about five turns round the drum, and is clamped to it at one point to prevent slipping, so that the drum can make about $2\frac{1}{2}$ turns in either direction. The two ends of the cable are led up over sheaves to the top of the dome, one being attached directly to the left-hand shutter and continued on round a sheave fixed to the right-hand side of the opening and then attached to the right-hand shutter. A pull on this rope will thus open both shutters. The second end of the rope is attached to the right-hand shutter and then carried round a sheave also fixed to the right-hand side of the opening and taken back to the left-hand shutter, so that a pull on this rope closes both shutters. On another portion of the winding drum a second rope is placed and carried to the lower part of the shutters in a similar manner, so that when the drum is rotated they are moved simultaneously from both the top and bottom ends.

The two larger rope wheels in Fig. 30 are used for operating the two wind screens, which are used to cover the openings above and below the telescope tube when the rolling shutters are open. These screens are made of sail cloth, 8ft. 10 in. wide, in which steel tubes are inserted in a transverse direction at intervals of about 4 ft. Part of the lower wind screen can be seen in the background in Fig. 3, on page 6, and two of the steel tubes are visible in this illustration. The ends of the tubes are fitted with rollers which run on tracks formed by $1\frac{3}{4}$-in. by $\frac{3}{8}$-in. flats fixed to the webs of the main girders, as shown in section in Fig. 12, on the Plate. The gear for operating the upper and lower wind screens is shown in Figs. 32 and 33, respectively, on page 10, from which it will be seen that the arrangements are generally similar to those employed for operating the rolling shutters, except that both wind screens are operated independently. Either screen can be pulled up or down, according to the direction of rotation of the rope wheels, by means of wire ropes passing over a series of sheaves on the main girder, as shown in Fig. 1, page 4. Any slack in the ropes can be taken up by adjusting sheaves mounted on long screwed rods, one of which is shown in Fig. 32. In use, the upper screen remains fully extended, it being pulled over into the left-hand side of the dome, as shown in Fig. 1, when observations are being made near the zenith; the upper screen can be seen in this position, towards the right in Fig. 2, on page 5. The lower screen, on the other hand, is arranged to fall into folds when the telescope is directed to a point near the horizon, as the roller bars approach each other at the lower end of the track. The latter is bent outwards at the lower end, as shown in Fig. 1, so that the folds hang clear of the lower platform and stairway.

In conclusion, we may mention that access to the lower platform is provided by a staircase suspended from, and rotating with, the dome, the lower end of this staircase terminating just above the level of a central platform supported on columns from the observatory floor. A staircase from the latter leads to the central platform, which gives convenient access to the circles on the polar axis, as well as to the finder and spectrograph. It can also be used for visual observations when the Cassegrainian optical system is employed.

LIST OF PUBLICATIONS.

No. 1. "Astronomical and Optical Instruments." A History of the Foundation of The Company and of its achievements in the British Optical Industry.

2. Description of a 7 metre solar spectrograph constructed for Pulkovo Observatory, Russia.

3. Description of a 40-in. Reflecting Telescope constructed for Simeis Observatory, South Russia.

4. Illustrated lists of Grubb-Parsons Optical Instruments.

5. Description of 18-in. Coelostat for Canberra Observatory, New South Wales.

6. Description of 36-in. Reflecting Telescope for the Royal Observatory, Edinburgh.

7. Description of 40-ft. Revolving Dome for Stockholm Observatory.

PRINTED BY HARRISON AND SONS, LTD., LONDON.

A.2.31